

Certifying DERs for the Grid: Utility Scale Inverter Testing

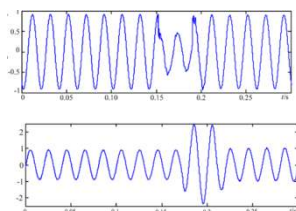
Integrating PV in Distributed Grids Workshop: Solutions and Technologies

Oct 23rd 2015, NREL

Soonwook Hong, Ph. D.
Solectria, A Yaskawa Company



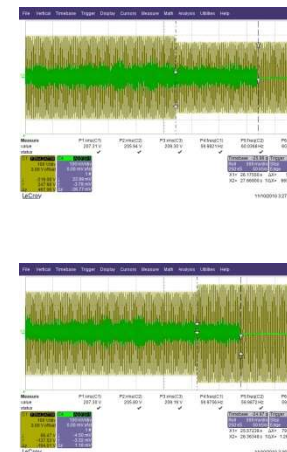
Abnormal Grid V/F Test: Protection functions



Abnormal Grid
Conditions



Power Electronics
Controller



Logic Level
Test

Logic level tests running at extreme temperature conditions

Exception: Anti-islanding and Open phase test are done with the actual grid

Industry Trends

Conventional UL/IEEE standards

- Focus on generation only
- Mostly safety related
- Logic level Protection test
- Individual Inverter operation

New standards (Rule 21, New IEEE, IEC)

- Mitigation plans for high penetration issues (reactive power, ride through operation,...)
- Performance oriented
how smart? how fast? how accurate?
- Much more detailed requirements for industry compliances.

UL1741SA Draft for ride through test:

“The input source shall be capable of supplying 150% of the rated input current of the EUT”

Input source requirement for future inverter test



NREL ESIF provides a great option for testing utility scale inverters.

Also, excited to hear that NREL opens the facility for certification test!

Continuous Partnership since 2013



ENERGY SYSTEMS INTEGRATION



ESI optimizes the design and performance of electrical, thermal, fuel, and water pathways at all scales.

ESI Partnerships: NREL + Solectria

NREL is partnering with solar inverter manufacturer Solectria at the ESIF to develop 500- and 750-kilowatt photovoltaic (PV) inverters with advanced features that can support the electric grid.

R&D Strategy

The ESIF's utility-scale power hardware allows Solectria to test its inverters using simulated utility grid and solar PV emulation so researchers can see the impact of the inverter's advanced features on power reliability and quality. This unique testing capability allows Solectria to test its inverter's controls and functionality at full power—and determine how its integration supports and impacts the grid under a variety of conditions.

Impact

This work supports the development of PV inverters that can provide bulk system support to utilities under fault conditions—which will ultimately allow for increased penetration of solar on the grid.



Solectria is leveraging the unique capabilities of the ESIF advanced inverter technology. Photo by Dennis Schroeder, NREL.



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Solectria

Solar inverter manufacturer Solectria is partnering with NREL to test its SGI-500 utility-scale photovoltaic (PV) inverter at the ESIF. The testing will focus on the inverter's response to frequency and voltage normal and abnormal conditions.

The ESIF's utility-scale power hardware-in-the-loop capability allows Solectria to loop its inverter into a real-world simulation environment so researchers can see the impact of the inverter's advanced features on power reliability and quality. This one-of-a-kind testing capability allows Solectria to test its inverter's controls and functionality at full power—and determine whether its integration changes the landscape of the grid.

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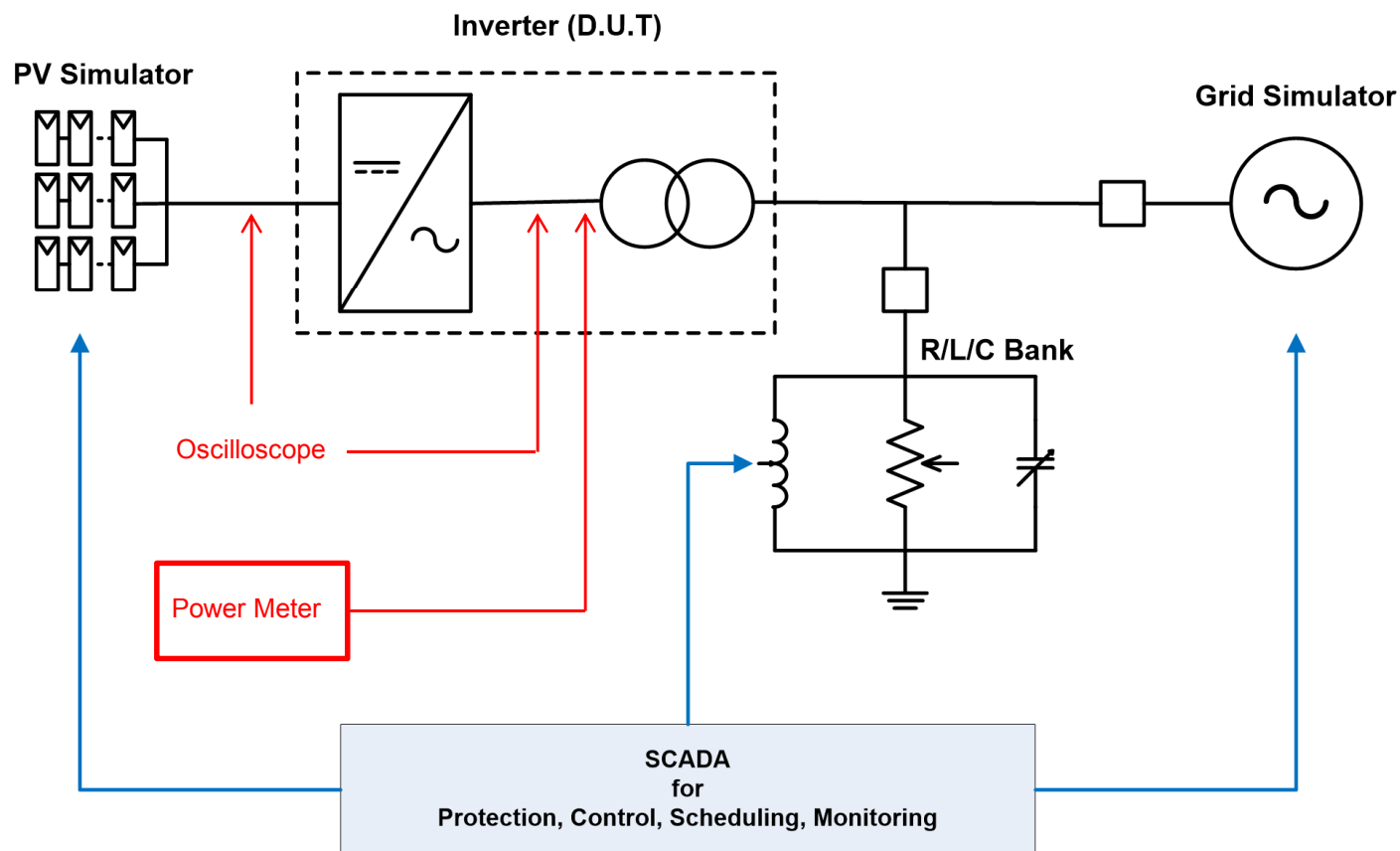


Started with DoE SunShot Initiative project with EPRI leadership

Test Setup



Test Setup Diagram



Personal Safety is No. 1 priority!



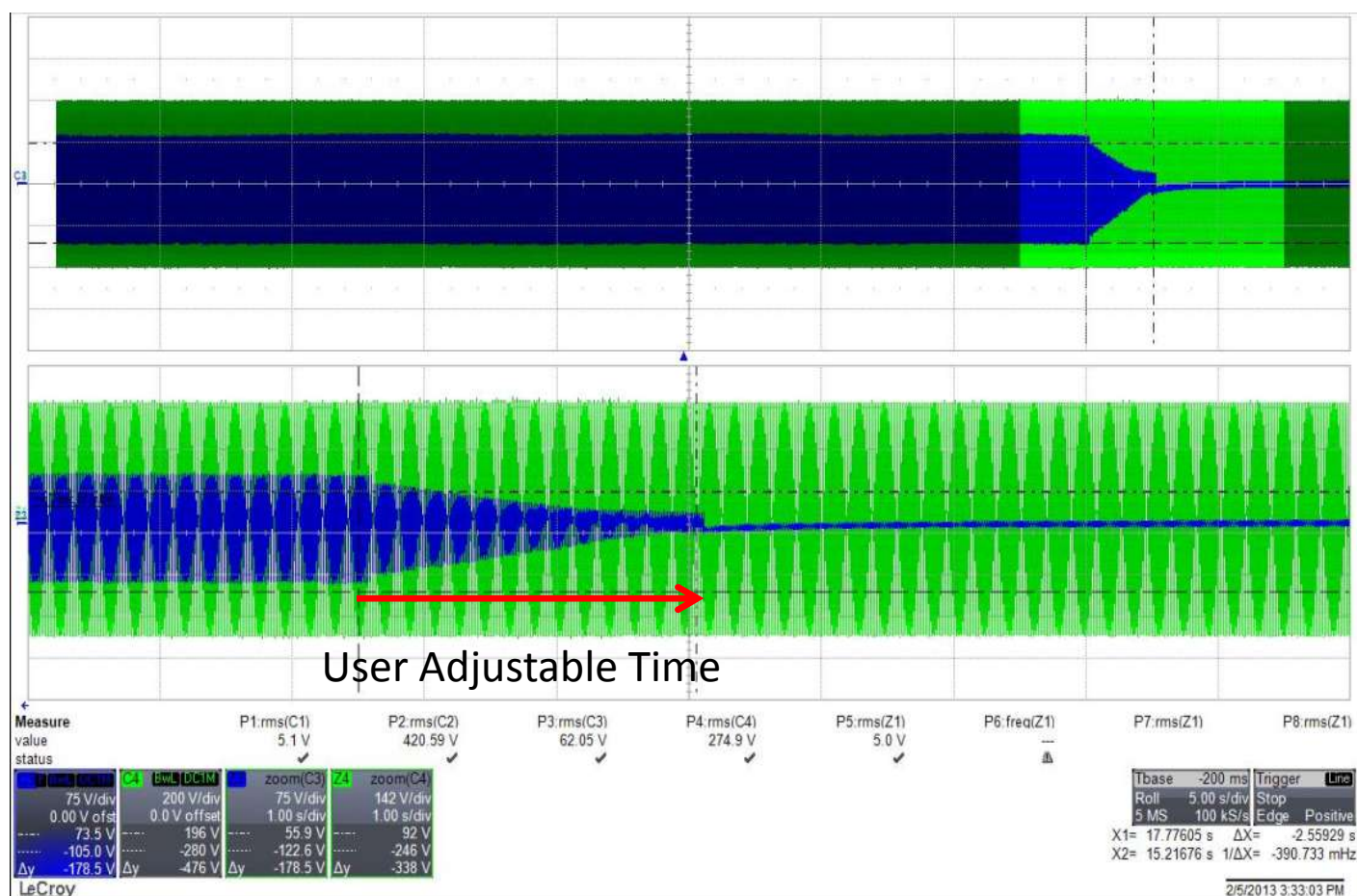
Sample Test Results

Steady State Operation with abnormal frequency



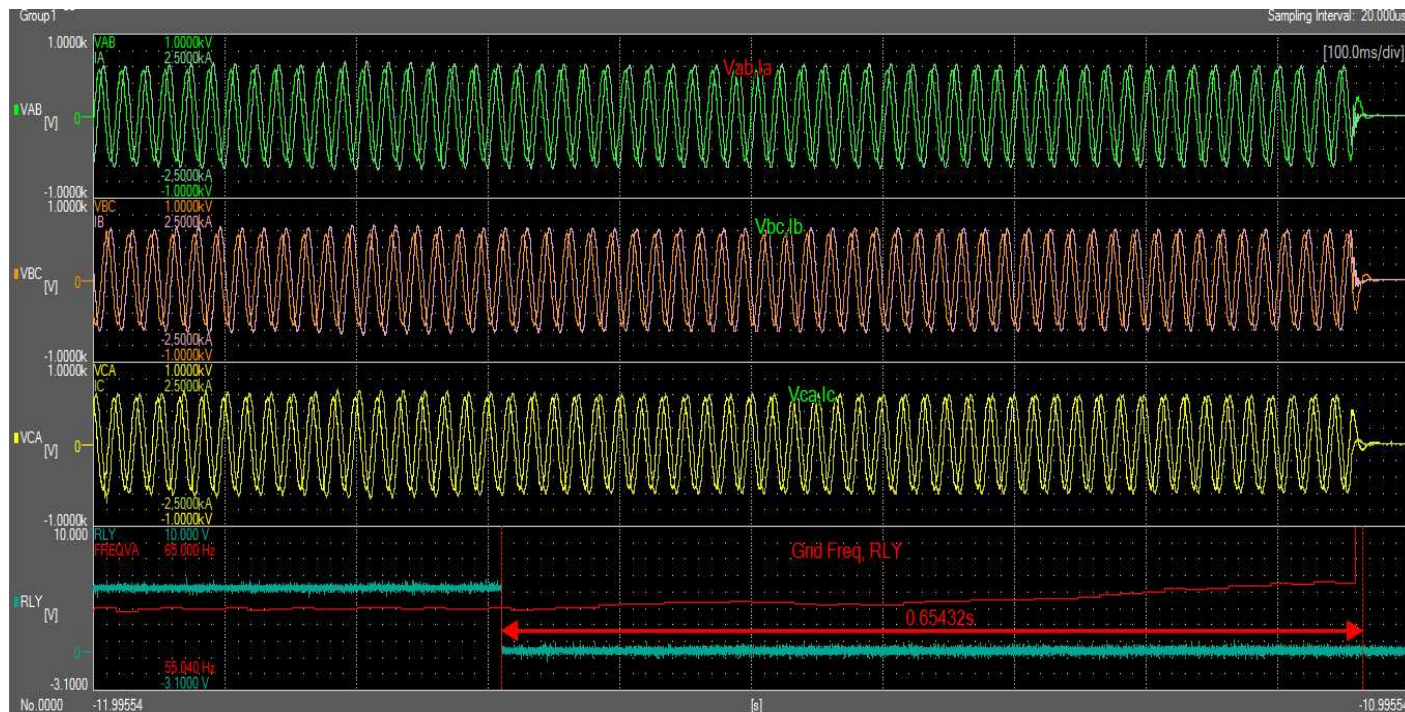
Magnetic Component operation verification

Remote Shutdown with controlled slew rate



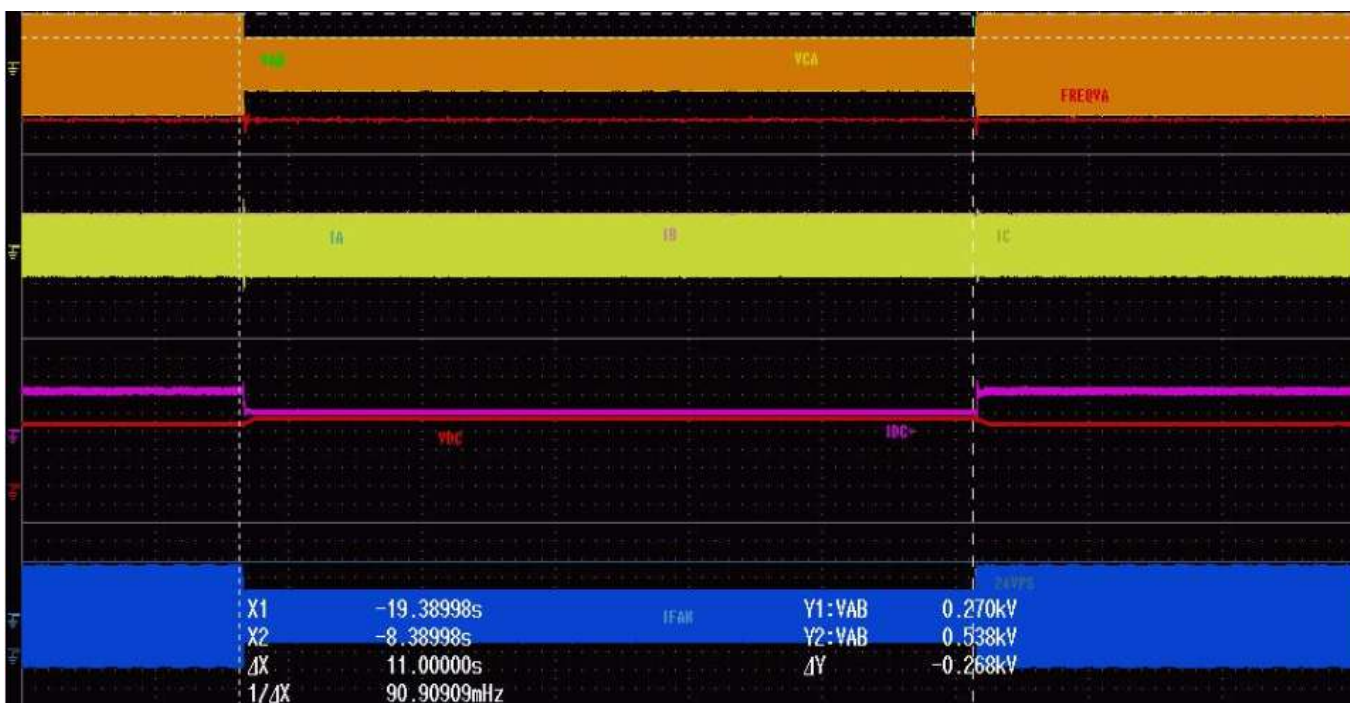
Remote shut down with programmable ramping

Protection with Grid supporting Function



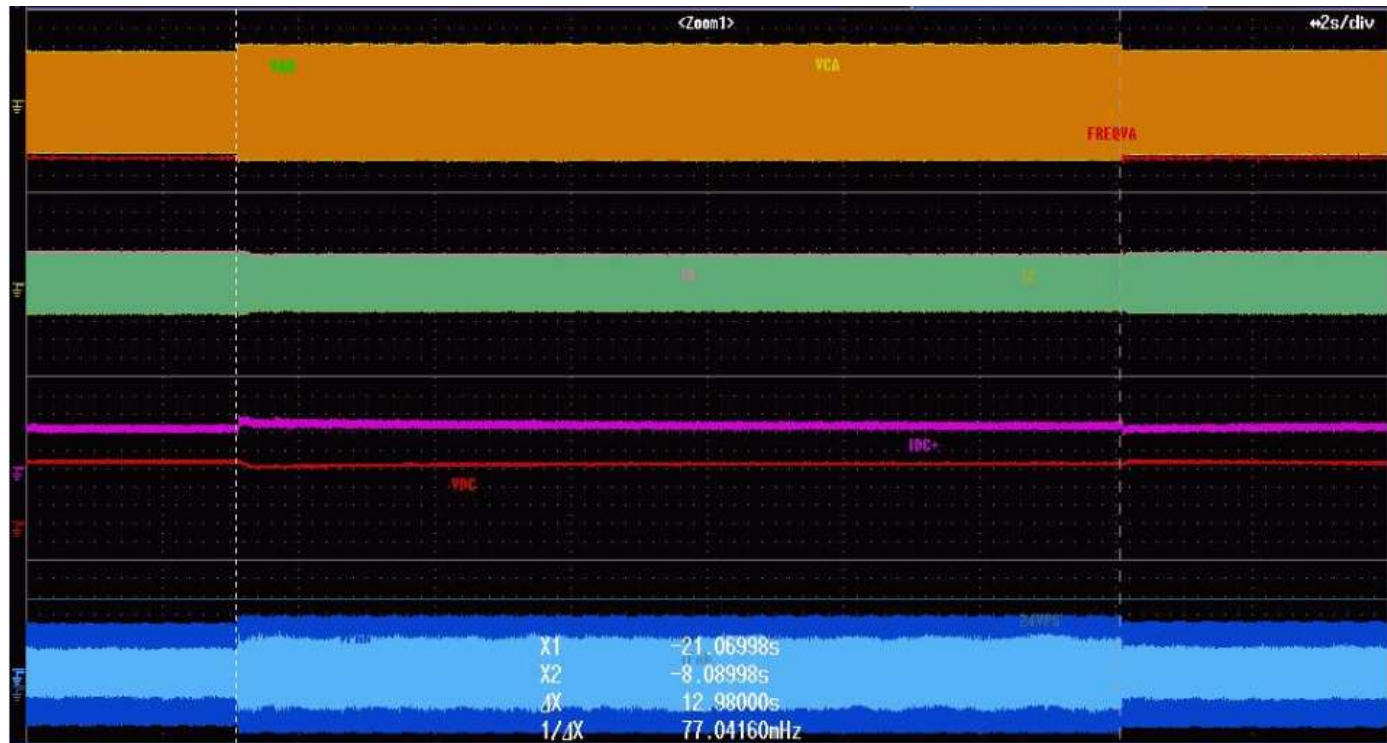
Anti-Islanding Detection while inverter operating at 0.8 PF

Functionality Test (LVRT)



Mandatory Operation with balanced 50% sag for 11sec

Functionality Test (HVRT)



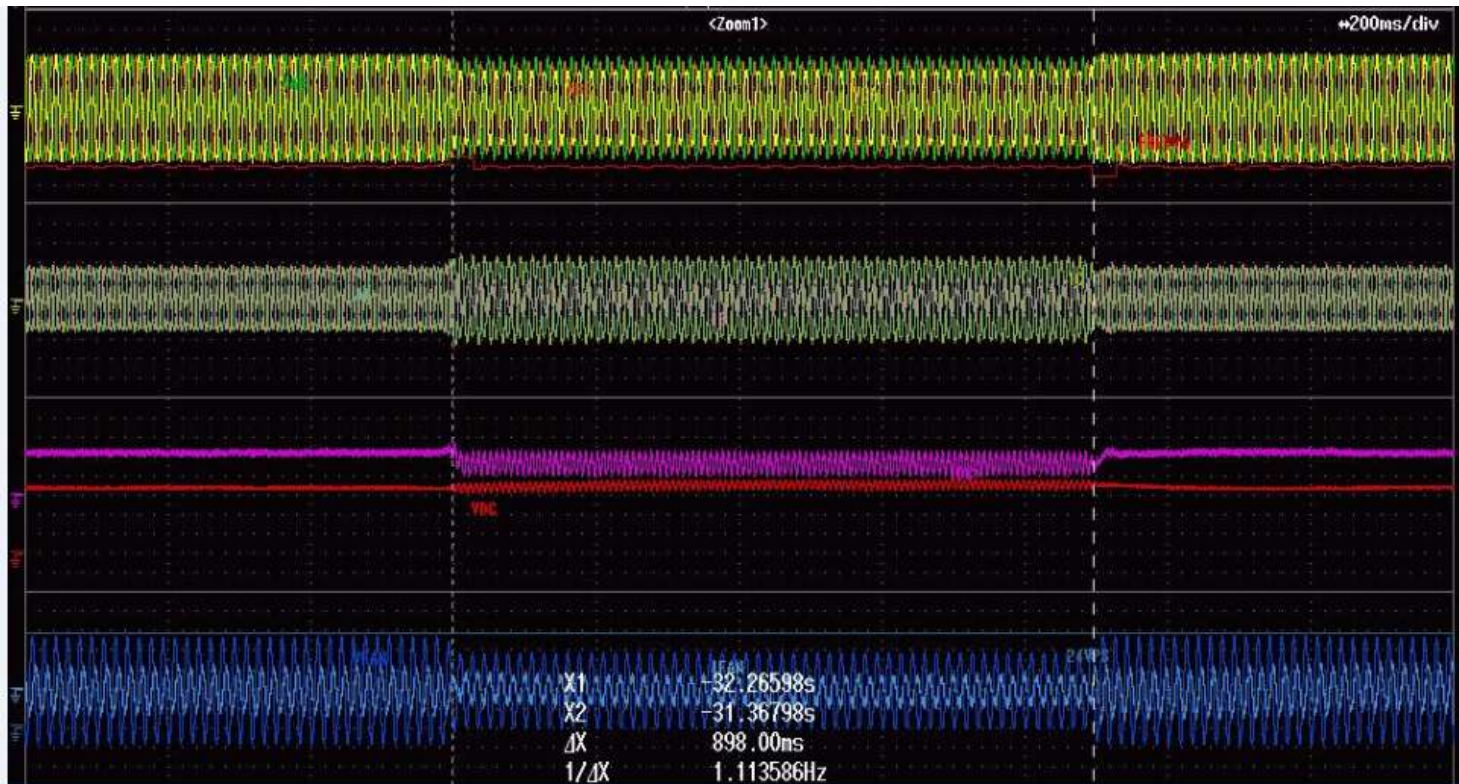
Mandatory Operation with balanced 115% swell for 13 sec

Inverter Transient Response



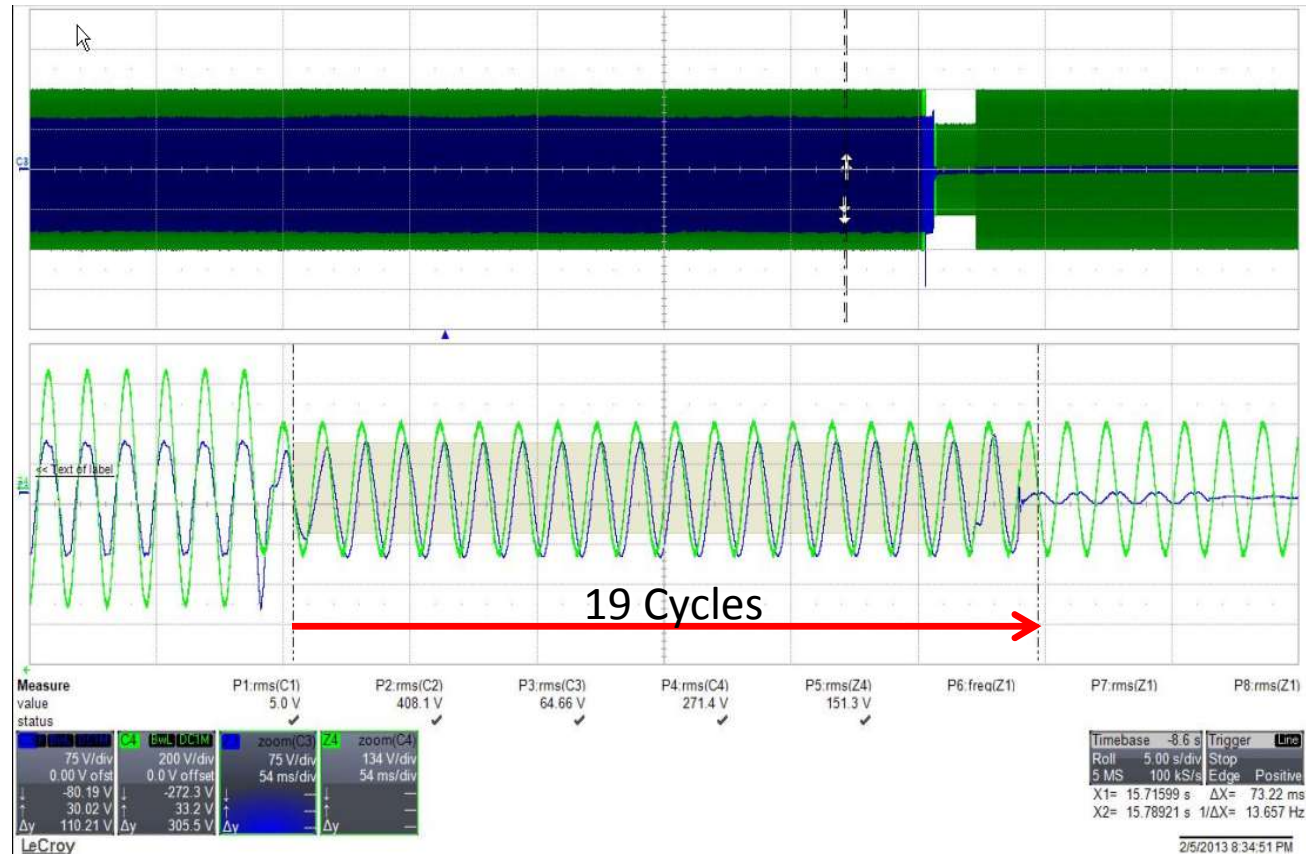
Current control loop bandwidth with 1 cycle 50% voltage sag.

Unbalanced Sag 50% for 1 sec



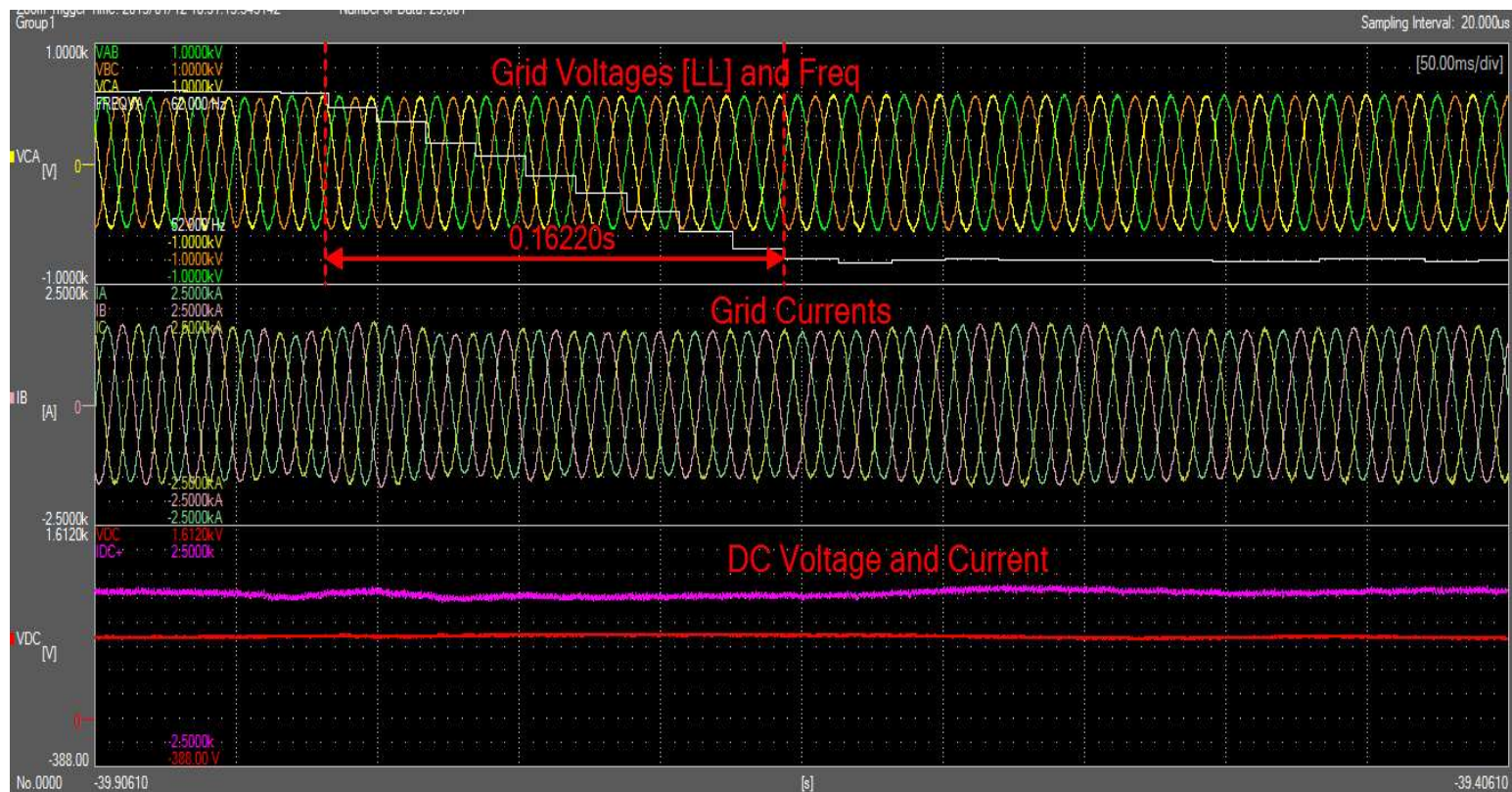
During unbalance condition, both ac and dc power is not constant, which generates ripple in the DC voltage

Trip Operation after actively riding through



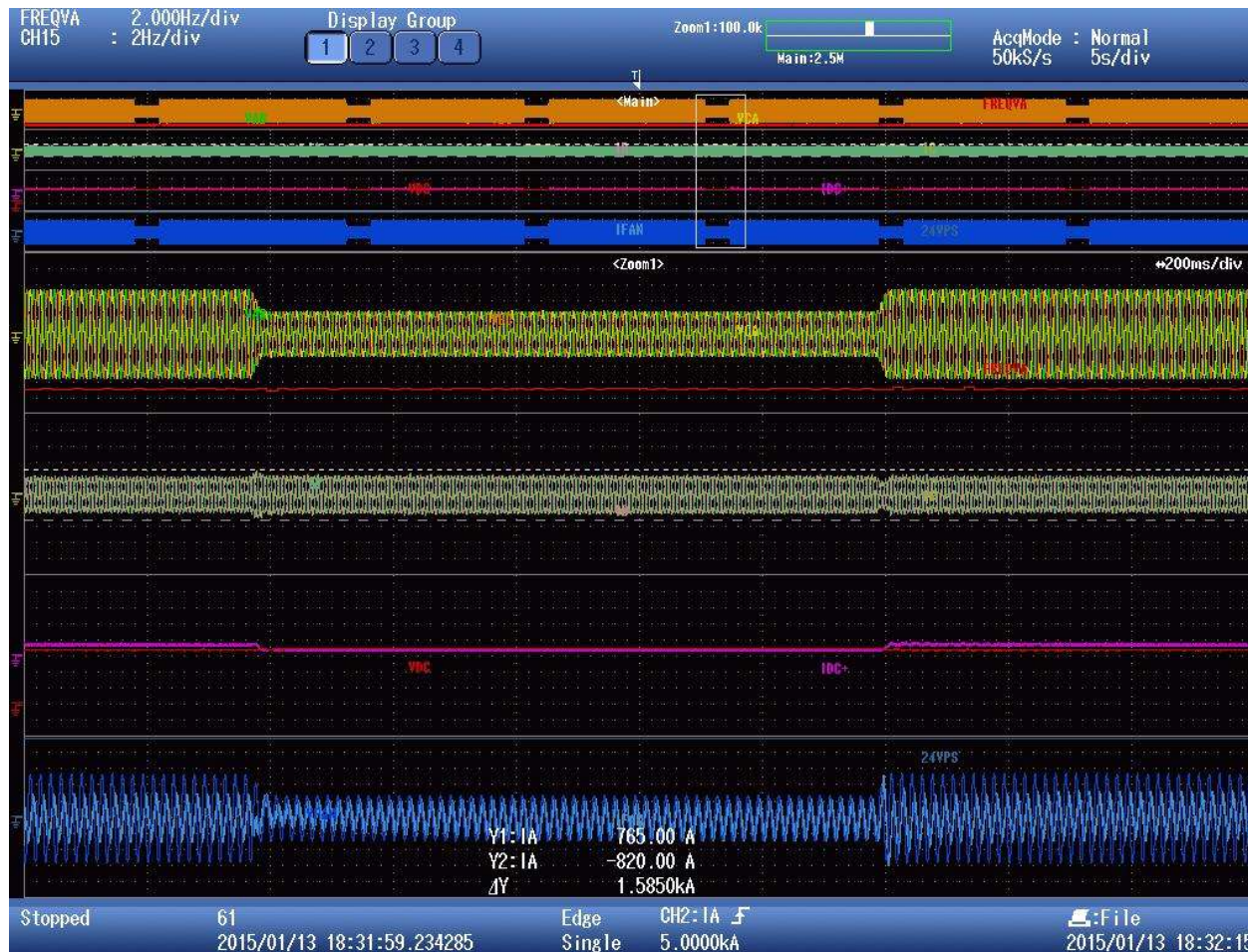
Ride through for 300msec with 45%, injecting Capacitive Reactive Current

Frequency Transient Test



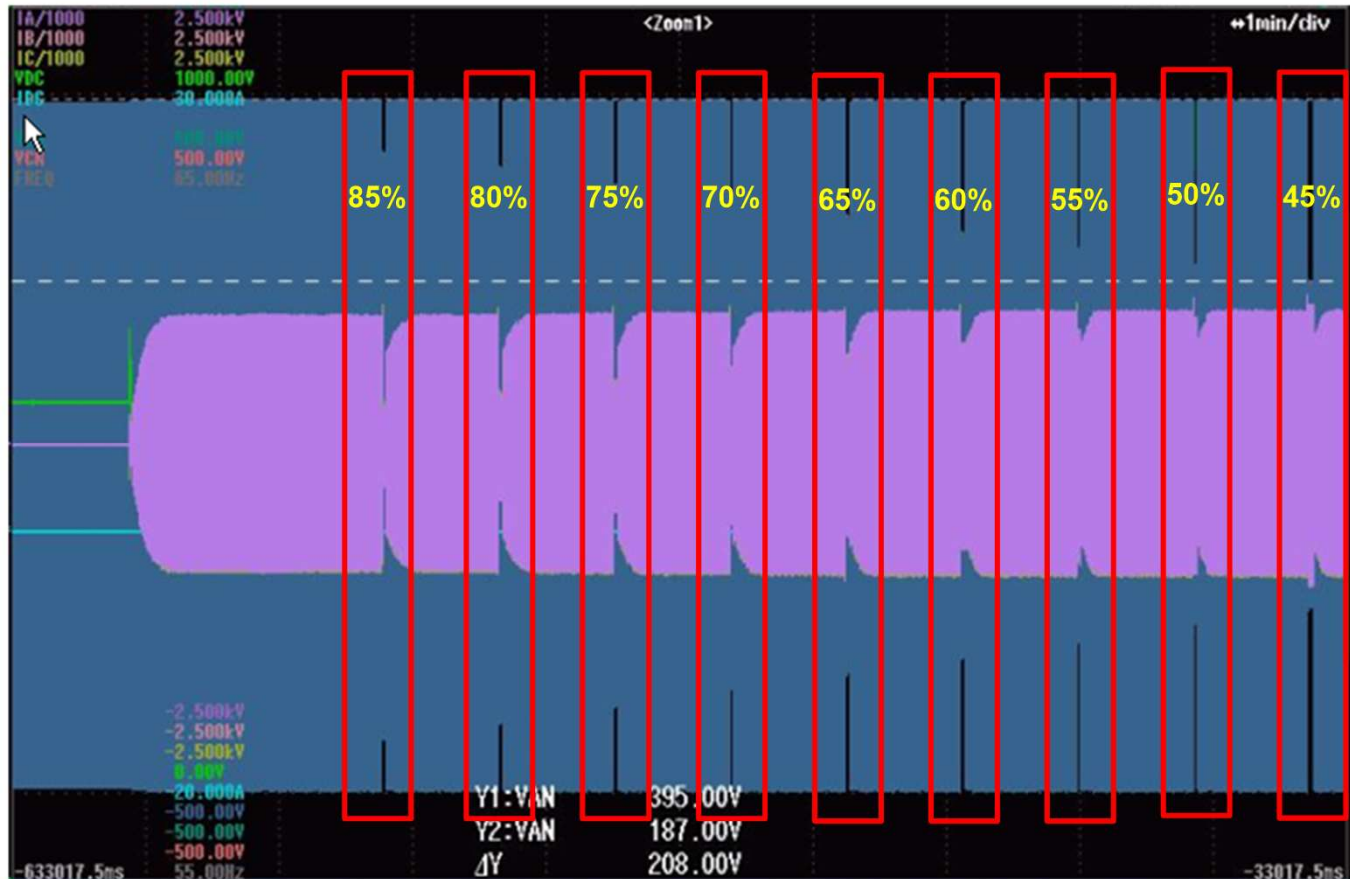
PLL Operation verification: 60Hz to 53Hz in 10 ac cycle

Test Automation

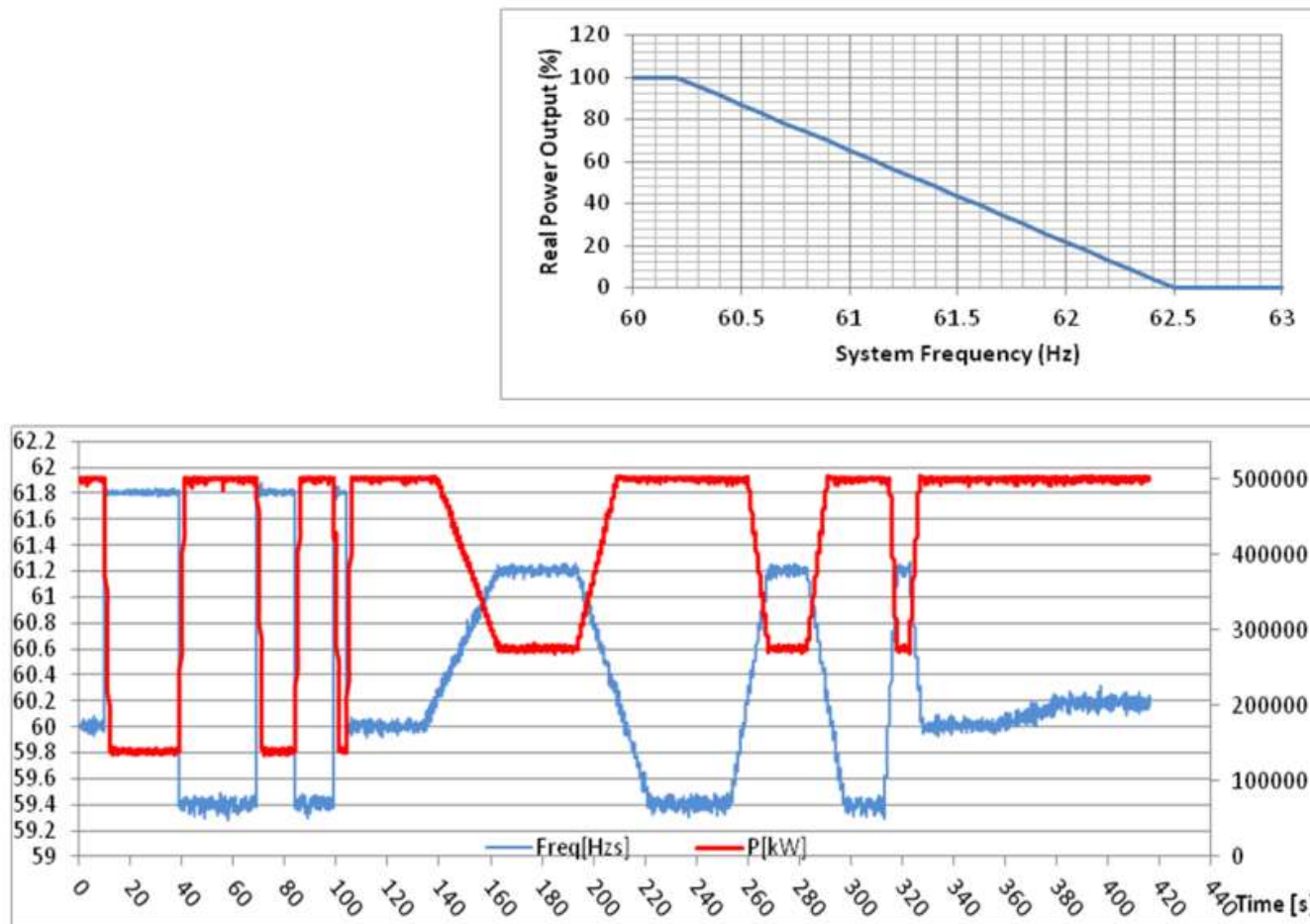


Mandatory Operation with balanced 50% sag for 11sec

Automated test with different sag levels



Automation for characterizing control dynamics



Freq-watt Function with Sandia Lab Test Protocol

Experience with NREL ESIF

- Great facility to test utility scale inverter based DERs available for the industry
- Timely available just before industry needs
- Technical Leadership and Support
- Great support from Coordination, Safety, Maintenance departments

Professional mindset for achievement with friendly working environment!

Expected Needs from Manufacturer's view

Hosting the certification test (with NRTL invitation) – already planned



Expanding the facility – already planned



Automated functional test: possible development with manufacturers

Automated certification test: possible DoE project for the industry

Thank you!

soonwook.hong@solectria.com